UNITED STATES PATENT AND TRADEMARK OFFICE

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
09/866,936	05/29/2001	Deane Yang	Kalotay-1	6572

7590 10/20/2005

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EXAMINER
HARBECK, TIMOTHY M

ART UNIT	PAPER NUMBER
3628	

DATE MAILED: 10/20/2005

Please find below and/or attached an Office communication concerning this application or proceeding.

PTO-90C (Rev. 10/03)

	Application No.	Applicant(s)
Office Action Summary	09/866,936	YANG ET AL.
	Examiner	Art Unit	
	Timothy M. Harbeck	3628	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE <u>3</u> MONTH(S) OR THIRTY (30) DAYS, WHICHEVER IS LONGER, FROM THE MAILING DATE OF THIS COMMUNICATION.
- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☐ Responsive to communication(s) filed on <u>*29 May 2001*</u>.

2a)☐ This action is **FINAL**.   2b)☒ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

4)☒ Claim(s) *1-26* is/are pending in the application.

    4a) Of the above claim(s) _____ is/are withdrawn from consideration.

5)☐ Claim(s) _____ is/are allowed.

6)☒ Claim(s) *1-26* is/are rejected.

7)☐ Claim(s) _____ is/are objected to.

8)☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

9)☐ The specification is objected to by the Examiner.

10)☒ The drawing(s) filed on *29 May 2001* is/are: a)☒ accepted or b)☐ objected to by the Examiner.

    Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

    Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

11)☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

12)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

    a)☐ All   b)☐ Some * c)☐ None of:

      1.☐ Certified copies of the priority documents have been received.

      2.☐ Certified copies of the priority documents have been received in Application No. _____.

      3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

    * See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☒ Notice of References Cited (PTO-892)
2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
3) ☒ Information Disclosure Statement(s) (PTO-1449 or PTO/SB/08) Paper No(s)/Mail Date *3/25/2002*.

4) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____ .
5) ☐ Notice of Informal Patent Application (PTO-152)
6) ☐ Other: _____ .

DETAILED ACTION

Claim Rejections - 35 USC § 103

The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all

obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

Claims 1-26 are rejected under 35 U.S.C. 103(a) as being unpatentable over

Lindahl ("Risk-Return Hedging Effectiveness Measures for Stock Index Futures," The

Journal of Futures Markets. New York: Aug 1991. Vol. 11, Iss.4; Pg 399, 11 pgs) in

view of Malliaris ("Tests of Random Walk of Hedge Ratios and Measures of Hedging

Effectiveness for Stock Indexes and Foreign Currencies," The Journal of Futures

Markets. Hoboken: Feb 1991. Vol.11, Iss. ; Pg 55, 14 pages).

Re Claim 1: Lindahl discloses a measure of hedging effectiveness comprising

the steps of:

- Determining a standard deviation of a hedged item (See abstract and

  Introduction)

- Determining a standard deviation of a combination of said hedged item

  and a hedging vehicle (See abstract and Introduction)

- Determining a ratio between the standard deviation of said hedged item

  and said standard deviation of said hedged item and said hedging vehicle

  (See abstract and introduction)

Lindahl does not explicitly disclose the steps wherein said standard deviation of said hedged item, said standard deviation of said hedged item and a hedging vehicle, and the ratio between the two represent changes in value over a known time frame.

Malliaris discloses a test of hedge ratios and measures of hedging effectiveness wherein it is implied that "hedges cannot consistently place perfect hedges and need to continuously readjust their hedges. This can be done by using appropriate computational methods that take into account the variable nature of the hedge ratio and the measure of hedging effectiveness (page 66)." Essentially this an admission that hedged items change over time, and for a hedge ratio to be truly effective, the change in value must be measured over time as well.

It would have been obvious to someone skilled in the ordinary art at the time of invention to include the teachings of Malliaris to that of Lindahl, so a better estimate of hedge effectiveness can be achieved. The computational methods used by Malliaris to take into account the variable nature of the hedge ratio could easily be applied to the ratio disclosed by Lindahl and would provide a better indication of effectiveness than the static measure.

Re Claim 2: Lindahl in view of Malliaris discloses the claimed method supra and while Malliaris does not explicitly disclose the step of determining a volatility measure as a complement to said ratio, Malliaris does hypothesize that volatility is an important factor that is ignored in many hedge ratios. The fact that hedges are variable over time is something that, according to Malliaris, must be factored into any test for effectiveness of hedge ratios (page 66). To do this, Malliaris suggests measuring changes in value

over time, which is essentially a measure of volatility. While not explicitly disclosing that

a volatility measure is determined, it could very readily be determined with information

available in the Malliaris method and further strengthen the current hypothesis.

Re Claim 3: Lindahl in view of Malliaris discloses the claimed method supra and

while the references do not explicitly disclose wherein said known time period is

selected from the group of monthly, quarterly and yearly this step would be obvious

because those are notoriously well known in the art as fractions of time in which

financial instruments are measured.

Re Claims 4-8: Lindahl in view of Malliaris discloses the claimed method supra

and while the references do not explicitly disclose the steps of claims 4-8, applicant in

his disclosure has admitted these claims as known prior art. These admissions include

- Wherein effectiveness is determined when said ratio is below a known

    level (Page 2, Paragraph 0105; below 125%)

- Wherein effectiveness is determined when said ratio is above a known

    level (Page 2, Paragraph 0105; above 80%)

- Wherein said known level is based upon conventional financial

    considerations (Page 2, Paragraph 0105, Guideline provided by FASB)

Since applicant has admitted that these steps were previously known in the art it

would have been obvious to apply them in the same manner to Lindahl in view of

Malliaris in order to determine the effectiveness of a hedge ratio.

Re Claims 8-14: Further system claims would have been obvious to perform previously rejected method claims 1-7 respectively and are therefore rejected using the same art and rationale.

Re Claims 15-26: Lindahl in view of Malliaris has been shown in the previously rejected claims 1-7 to disclose the claimed invention. The references do not however discuss the automation of said invention. It would have been obvious to one having skill in the art at the time the invention was made to, since it has been held that broadly providing a mechanical or automatic means to replace manual activity which has accomplished the same result involves only routine skill in the art. *In re Venner*, 120 USPQ 192.

Conclusion

Any inquiry concerning this communication or earlier communications from the examiner should be directed to Timothy M. Harbeck whose telephone number is 571-272-8123. The examiner can normally be reached on M-F 8:30-5:00.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Hyung S. Sough can be reached on 571-272-6799. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the

Patent Application Information Retrieval (PAIR) system. Status information for

published applications may be obtained from either Private PAIR or Public PAIR.

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For more information about the PAIR system, see http://pair-direct.uspto.gov. Should

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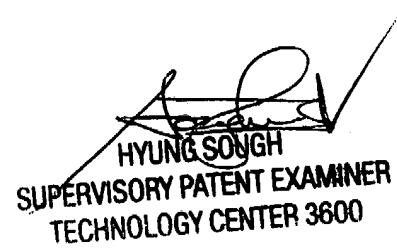
HYUNG SOUGH
SUPERVISORY PATENT EXAMINER
TECHNOLOGY CENTER 3600

	Docket Number (Optional)		Application Number	
INFORMATION DISCLOSURE CITATION *(Use several sheets if necessary)*	Kalotay-1		09/866,936	
	Applicant(s)			
	Deane Yang et al.			
	Filing Date		Group Art Unit	
	May 29, 2001		2164	

U.S. PATENT DOCUMENTS

*EXAMINER INITIAL	REF	DOCUMENT NUMBER	DATE	NAME	CLASS	SUBCLASS	FILING DATE IF APPROPRIATE

FOREIGN PATENT DOCUMENTS

	REF	DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUBCLASS	Translation YES	Translation NO

OTHER DOCUMENTS   *(Including Author, Title, Date, Pertinent Pages, Etc.)*

(initials)		"Testing Hedge Effectiveness for FAS 133: The Volatility Reduction Measure" by Andrew Kalotay and Leslie Abreo, *Journal of Applied Corporate Finance* (Winter 2001).
		"FAS 133: Hedge Effectiveness Testing" by Andrew Kalotay and Leslie Abreo, Reuters Risk Review, (3rd and 4th Quarters 2000, Issue #3, Volume #2)
(initials)		"Effectiveness Using Statisitics: Take 4" by Nilly Essaides, *International Treasurer* (May 21, 2001)
		"Earning Impact of Derivatives Under Hedge Accounting" by Andrew Kalotay and Leslie Abreo, *FAS 133 and the New Derivatives Accounting Landscape*

EXAMINER	DATE CONSIDERED
(signature)	10/05/2005

EXAMINER: Initial if citation considered, whether or not citation is in conformance with MPEP Section 609; Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

INFORMATION DISCLOSURE CITATION *(Use several sheets if necessary)*	**Docket Number (Optional)** Kalotay-1		**Application Number** 09/866,936	
	Applicant(s) Deane Yang et al.			
MAR 2 5 2002	**Filing Date** May 29, 2001		**Group Art Unit** 2164	

U.S. PATENT DOCUMENTS

*EXAMINER INITIAL	REF	DOCUMENT NUMBER	DATE	NAME	CLASS	SUBCLASS	FILING DATE IF APPROPRIATE
					COPY OF PAPERS ORIGINALLY FILED		
					RECEIVED		
					MAR 2 9 2002		
					Technology Center 2100		

FOREIGN PATENT DOCUMENTS

	REF	DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUBCLASS	Translation	
							YES	NO

OTHER DOCUMENTS   *(Including Author, Title, Date, Pertinent Pages, Etc.)*

(initials)		Presentation to Professional Associations: "FAS 133 Hedge Effectiveness Testing: The Volatility Reduction Measure (VRM)" *Sixth Annual Fixed Income Summit* (Palm Beach, Florida, December 14, 2000)
(initials)		"The Volatility Reduction Measure" by Andrew Kalotay, March 2001, Derivatives Strategy, *Columns*
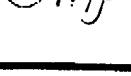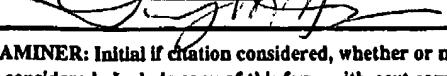
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		Application/Control No.	Applicant(s)/Patent Under Reexamination
Notice of References Cited		09/866,936	YANG ET AL.
		Examiner	Art Unit	
		Timothy M. Harbeck	3628	Page 1 of 1

U.S. PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Name	Classification
	A	US-			
	B	US-			
	C	US-			
	D	US-			
	E	US-			
	F	US-			
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FOREIGN PATENT DOCUMENTS

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	N					
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	R					
	S					
	T					

NON-PATENT DOCUMENTS

*		Include as applicable: Author, Title Date, Publisher, Edition or Volume, Pertinent Pages)
	U	Mary Lindahl, "Risk-Return Hedging Effectiveness Measures for Stock Index Furtures; INTRODUCTION," The Jornal of Futures Markets, New York: Aug 1991. Vol.11, Iss. 4; pg 399, 11 pgs.
	V	A.G. Malliaris and Jorge Urrutia, "Tests of Random Walk of Hedge Ratios and Measures of Hedging Effectiveness for Stock Indexes and Forein Currencies," The Journal of Futures Markets, Hoboken: Feb 1991. Vol.11, Iss. 1; pg 55, 14 pgs.
	W	
	X	

*A copy of this reference is not being furnished with this Office action. (See MPEP § 707.05(a).)
Dates in MM-YYYY format are publication dates. Classifications may be US or foreign.

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Tests of Random Walk of Hedge Ratios and Measures of Hedging Effectiveness for Stock Indexes and Foreign Currencies

Malliaris, A. G., *Urrutia, Jorge*. **The Journal of Futures Markets**. Hoboken: Feb 1991.Vol.11, Iss. 1; pg. 55, 14 pgs

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Subjects:	Studies, Stock index futures, Statistical analysis, Random walk theory , Hedging, Foreign exchange, Financial ratios, Stock Index Futures, Foreign Exchange
Classification Codes	9130 Experimental/theoretical treatment, 3400 Investment analysis, 1130 Economic theory
Author(s):	Malliaris, A. G. 🕊️ profile, Urrutia, Jorge 🕊️ profile
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Abstract (Document Summary)

The random walk hypothesis model is tested with 2 models. One model is based on the traditional methodology of Dickey and Fuller (1979, 1981) and the other follows the variance-ratio test of Lo and MacKinlay (1988). The data correspond to weekly spot prices and futures prices for the nearby contracts for the Standard & Poor's 500 Index, the New York Stock Exchange Index, the UK pound, the German mark, the Japanese yen, and the Swiss franc. Hedge ratios and measures of **hedge effectiveness** are generated by means of a moving window regression procedure. The empirical tests confirm the hypothesis that the hedge ratios and the measures of hedging **effectiveness** follow a random walk. Findings reinforce previous research confirming market efficiency in spot and futures markets. The major implication is that hedgers cannot consistently place perfect hedges and need to continuously readjust their hedges. This can be done by using appropriate computational methods that take into account the variable nature of the **hedge** ratio and the measurement of hedging **effectiveness**.

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Subjects:	☐ Studies ☐ Stock index futures ☐ Statistical analysis ☐ Random walk theory ☐ Hedging ☐ Foreign exchange ☐ Financial ratios ☐ Stock Index Futures ☐ Foreign Exchange
Classification Codes	☐ 9130 Experimental/theoretical treatment ☐ 3400 Investment analysis ☐ 1130 Economic theory
Author(s):	☐ Malliaris, A. G. ☐ Urrutia, Jorge
Language:	☐ English
Publication title:	☐ The Journal of Futures Markets

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Tests of Random Walk of Hedge Ratios and Measures of Hedging Effectiveness for Stock Indexes and Foreign Currencies

A. G. Malliaris
Jorge Urrutia

INTRODUCTION

Hedging theory in futures markets is developed in Working (1953, 1962), Johnson (1960), Stein (1961), and more recently, Rutledge (1972), Ederington (1979), and Franckle (1980). According to the portfolio theory approach to hedging, the hedge ratio and the measure of hedging effectiveness correspond to the regression coefficient, B, and the coefficient of determination, R^2, obtained from regressing the spot price changes on futures price changes. The coefficients B and R^2 are extensively examined.[1] However, previous studies of hedging performance of futures markets are subject to criticism because they are based on the assumption that the regression coefficient, which corresponds to the hedge ratio, is stable over the whole sample period. Indeed, Grammatikos and Saunders (1983), find that the hedge ratios for five major foreign currency futures are unstable over time. This article further explores the nonstationarity of the hedge ratio and the measure of the hedging effectiveness.

[1] Hedge ratios and measures of hedging effectiveness are estimated for GNMA futures by Ederington (1979), Hill, Liro, and Schneeweis (1983); for foreign currency futures by Hill and Schneeweis (1982), Grammatikos and Saunders (1983) and Grammatikos (1986); for T-bond futures by Hill and Schneeweis (1984); for CD futures by Overdahh and Sterleaf (1986); for T-bill futures by Ederington (1979), Franckle (1980), and Howard and D'Antonio (1984); and for stock market index futures by Figlewski (1984, 1985), and Junkus and Lee (1985).

A. G. Malliaris is the Walter F. Mullady, Sr. Professor of Economics at Loyola University of Chicago.

Jorge Urrutia is an Assistant Professor of Finance at Loyola University of Chicago.

The random walk hypothesis is tested with two models. One is based on the traditional methodology of Dickey and Fuller (1979, 1981) and the other follows the approach of Lo and MacKinlay (1988), known as the variance-ratio test. The empirical results confirm the random walk hypothesis for two stock index futures: Standard and Poor's 500 and New York Stock Exchange; and for four foreign currency futures: British Pound, German Mark, Japanese Yen, and Swiss Franc. The findings imply that hedgers cannot consistently place optimal hedges and that dynamic hedging techniques must be considered.

HYPOTHESIS OF RANDOM WALK

The main purpose of the article is to detect patterns in the instability of the coefficients B and R-squared, postulating that they vary randomly over time. Specifically, it is claimed that the hedge ratio and the measure of hedging effectiveness follow a random walk process.

The concept of a random walk is much more precise in financial analysis than the notion of instability. Authors such as Grammatikos and Saunders (1983) use the term "unstable hedge ratios" to mean that these ratios are not constant over time. In mathematical economic analysis the notion of instability is given a more precise meaning. Numerous definitions, theorems and applications of stability and instability are presented in Brock and Malliaris (1989). Intuitively, one can say that the sequence of hedge ratios $B_0, B_1, B_2, B_3, \ldots$ is unstable if the absolute deviations of these hedge ratios from the equilibrium hedge ratio become large after a certain time period. Clearly, it is difficult to test this notion of instability for at least two reasons: First, one needs a very long sequence and secondly, a precise meaning of "equilibrium hedge ratio" needs to be established.

Attention is devoted here to the nonconstant behavior of hedge ratios and coefficients of hedging effectiveness in terms of random walk, a notion familiar to financial analysts. Random walk may eventually lead to instability but that instability need not necessarily imply random walk. One reason for studying the random walk behavior is the methodological clarification it provides of the time series behavior of the hedge ratio and coefficient of hedging effectiveness.

There are additional reasons for interest in random walk. First, in an efficient market, changes of spot prices over time are random and reflect the arrival of new information. In other words, price changes on any particular day are uncorrelated with past historical price changes. Empirical research in futures markets suggests that futures price changes also follow a random walk, reflecting efficiency in futures markets as well.[2] The hedge ratio is the ratio of dollar amounts invested in a spot asset and a futures contract. It is reasonable to assume that the behavior of this ratio reflects the behavior of these prices. Therefore, given that prices follow a random walk process, one can also expect the hedge ratio to vary randomly over time.

Second, the random walk behavior of the hedge ratio may be explained by the theories of speculation and the effects of such speculation on price changes on both cash and futures markets. There are, in general, two theories about the effects of speculation on price variability. One theory claims that speculation increases price variability because speculators tend to buy as prices are rising and tend to sell as

[2]Empirical evidence of the random walk hypothesis for security prices is reported, among others, by Fama (1965), and Fama and Blume (1966); and, for futures markets by Fama (1976), Cornell (1977), and others.

prices are falling, generating a bandwagon effect which contributes to larger swings in price volatility. The opposing theory argues that speculation reduces price variability and has been defended by Milton Friedman (1953) who argues that only unprofitable speculation can have a destabilizing effect on prices. These theories are reviewed extensively by Tirole (1989). Simply put, this article assumes that the stability or instability of speculation, with similar or dissimilar intensity in cash and futures markets, may cause hedge ratios and coefficients of hedging effectiveness to follow random walks.

Third, the random walk behavior of the hedge ratio may be caused by differences in the microstructure of cash and futures markets. In this article, spot prices are determined in dealership markets with futures prices formulated in open outcry auction markets. There is an increasing literature that emphasizes the role of different trading mechanisms with special emphasis given to the role of "noise" and "feedback" traders on price formulation and the time series properties of such prices. A representative article in this literature is Cutler, Poterba, and Summers (1990). It seems reasonable to postulate that such differences in the microstructure of cash and futures markets and dissimilarities in trading mechanisms and types of traders may cause hedge ratios to vary over time.

DATA

The data correspond to weekly spot prices and futures prices for the nearby contracts (0–3 months) for the following instruments: (i) Stock Indexes: Standard and Poor's 500 Index, and New York Stock Exchange Index; (ii) Foreign Currencies: British Pound, German Mark, Japanese Yen, and Swiss Franc.

The time periods under study extend from March 4, 1980 through December 27, 1988 for the foreign currency instruments and, from January 1, 1984 through December 27, 1988 for the stock index instruments. The futures prices are Tuesday closing prices (Monday or Wednesday closing prices are used when a Tuesday closing price is missing) obtained from the Wall Street Journal.

METHODOLOGY AND EMPIRICAL RESULTS

First, hedge ratios and measures of hedging effectiveness are generated by means of a moving window regression procedure. Second, the hypothesis that the hedge ratio and the measure of hedging effectiveness follow a random walk process is tested by means of two models. The models are based on the Dickey and Fuller methodology and the variance-ratio approach of Lo and MacKinlay.

Moving Window Regression Procedure

Estimates of the hedge ratio and the measure of hedging effectiveness are obtained by running OLS regressions of the change of the spot price on the change of the corresponding futures price; that is:

$$S_t - S_{t-k} = A + B(F_t - F_{t-k}) + \epsilon_t \qquad (1)$$

where:

S_t, S_{t-k} = spot prices at time t and $t - k$, respectively.
F_t, F_{t-k} = futures prices at time t and $t - k$, respectively.
k = the length of hedging horizon measured in weeks.

In Eq. (1), the regression coefficient, B, and the coefficient of determination, R^2, correspond to the hedge ratio and the measure of hedging effectiveness, respectively. Since the behavior of the hedge ratio, over time, is of interest, it is assumed that for each contract the hedging horizon, k, is two-weeks.[3] The regressions are run using changes in cash and futures prices.[4]

B's and R^2's are generated using an overlapping or moving window regression procedure[5] in two steps. First, the hedge ratios and measures of hedging effectiveness are initially estimated for a one-year period: March 1980–February 1981, for foreign currencies, and January 1984–December 1984 for stock indexes. They are, subsequently, reestimated every quarter by adding a new quarter of spot and futures data and deleting the initial quarter's data and keeping a one-year estimation period. In this way, by regressing the change of the spot price on the change of the futures price, (for a two-week hedging horizon) moving B's and R^2's are estimated for each quarter.[6]

RANDOM WALK TESTS

The data used in testing for random walk correspond to the hedge ratios and measures of hedging effectiveness obtained from the moving window regressions.

Dickey and Fuller Tests of Random Walk

To test for random walk using the Dickey and Fuller methodology the following regressions are run:

$$\text{Full: } Y_t = b_0 + b_1 Y_{t-1} + b_2 T + \epsilon_t$$
$$\text{Reduced: } Y_t - Y_{t-1} = b_2 T + \epsilon_t \qquad (2)$$

where:

Y_t, Y_{t-1} = hedge ratio or measure of hedging effectiveness.
T = time trend.
ϵ_t = residual term at time t.

The null hypothesis that the hedge ratio and the measure of hedging effectiveness follow random walks, corresponds to $H_0: (b_0, b_1) = (0, 1)$ and is tested with an F-test based on a distribution suggested by Dickey and Fuller (1981). The results, presented in Table I for the hedge ratios and in Table II for the measures of hedging effectiveness, show that one cannot reject the null hypothesis at the 1% or 5% levels of significance. That is, the results of the Dickey and Fuller tests presented in

[3]The two-week hedging horizon is the most commonly found assumption in the futures hedging literature. See, i.e., Grammatikos and Saunders (1983).

[4]Price changes are used, among others, by Ederington (1979), Franckle (1980), Dale (1981), and Grammatikos and Saunders (1983). Other researchers, such as McCabe and Franckle (1983), Hammer (1988), use percentage changes or natural logarithm of prices. Some tests using percentage price changes were conducted (not reported here) which do not change the results.

[5]The same procedure is used by Grammatikos and Saunders (1983).

[6]The hedge ratios and measures of hedging effectiveness obtained from this procedure exhibit major deviations from the average long-term B's and R^2's. The average long-term hedge ratios and measure of hedging effectiveness are estimated by running the OLS regression (1) for the full time periods. These results indicate that the hedge ratio and the measure of hedging effectiveness are unstable over time, which confirms earlier results found in the literature. The average long-term B's and R^2's and the B's and R^2's estimated from the moving window regression procedure are not reported here for the sake of space but they are available from the authors upon request.

these two tables indicate that the hedge ratios and the measures of hedging effectiveness follow random walk processes.

Variance Ratio Tests of Random Walk

The regression models postulated in Eq. (2) assume that the disturbances ϵ_t are independent and identically distributed gaussian random variables. However, there is mounting evidence that financial time series posses time-varying volatilities and deviate from normality. Lo and MacKinlay (1988) have developed a test-statistic for random walk which is sensitive to correlated price changes but which is otherwise robust with respect to many forms of heteroskedasticity and nonnormality of the random disturbances. This new test of random walk is known as the variance-ratio test. This article adopts the Lo and MacKinlay approach to reinforce the results of the Dickey and Fuller test and to provide further empirical evidence that the hedge ratios and the measures of hedging effectiveness are governed by a random walk behavior.

The intuition behind the variance ratio test is the following: If the natural logarithm of a time series denoted Y_t, is a pure random walk of the form

$$Y_t = \mu + Y_{t-1} + \epsilon_t$$

then, the variance of its k-differences grows linearly with the difference k. For example, the variance of monthly sampled series must be four times as large as the variance of a weekly sampled series. That is, if the series follows a random walk, it must be the case that the variance of the k-differences is k times the variance of the first-difference:

$$VAR(Y_t - Y_{t-k}) = kVAR(Y_t - Y_{t-1}).$$

Therefore, under the random walk hypothesis, the ratio of $(1/k)$ times the variance of the k-differences over the variance of the first-differences is expected to be equal to one. In other words, a test of random walk is equivalent to testing the null hypothesis:

$$H_0:(1/k)VAR(Y_t - Y_{t-k})/VAR(Y_t - Y_{t-1}) = 1.$$

The results of the variance ratio tests shown in Table III and IV indicate that one cannot reject the null hypothesis. In fact, the variance ratios are not statistically different from one at the 5% level of significance. Thus, the results of the variance ratio tests reinforce those reported by the Dickey and Fuller methodology and indicate the robustness of the random walk hypothesis for the hedge ratios and the measures of hedging effectiveness.

A slightly different interpretation of the variance ratio test is given by Cochrane (1988) who argues that a series can be decomposed into fluctuations that are partly temporary and partly permanent. The random walk carries the permanent component of a change and the stationary series carries the temporary part of a change. In this case, the $(1/k)VAR(Y_t - Y_{t-k})$ should settle down to the variance of the shock of the random walk or permanent component. Therefore, the variance ratio corresponds to an estimate of the measure of the random component of the series. Following Cochrane's argument, the large variance ratios reported in Table III and IV seem to indicate that hedge ratios and measures of hedging effectiveness contain a large permanent or random walk component and a small temporary component.

Table I

TEST OF RANDOM WALK OF THE HEDGE RATIO

Model: Full: $Y_t = b_0 + b_1 Y_{t-1} + b_2 T + \epsilon_t$ Reduced: $Y_t - Y_{t-1} = b_2 T + \epsilon_t$

$$H_0: (b_0, b_1) = (0, 1) \qquad F = \frac{(SSE_R - SSE_F)/2}{SSE_F/(n-3)}$$

Futures Contract	Model	Coefficients of Independent Variables (t values and std. errors in parenthesis)			R^2 (adj.) (F) (pr.)	SSE	F	F critical[c] 5%, 1%
		b_0	b_1	b_2				
British Pound	Full	0.34421 (3.561) (0.0966)	0.62142 (5.262) (0.11809)	0.00064 (0.402) (0.00159)	0.5586 (19.98) (0.0001)	0.13089	6.665[b]	5.18
	Reduced			0.00022 (0.289) (0.00075)	0.0028 (0.084) (0.774)	0.19320		7.18
German Mark	Full	0.26772 (2.40) (0.11137)	0.71606 (5.64) (0.12688)	0.00028 (0.320) (0.00088)	0.6398 (27.642) (0.0001)	0.03328	3.664[a]	5.18
	Reduced			0.0000004 (0.001) (0.00035)	0.0001 (0.00) (0.9991)	0.04199		7.18
Japanese Yen	Full	0.14813 (1.50) (0.09888)	0.81930 (7.62) (0.10757)	0.00064 (0.33) (0.00191)	0.6556 (29.55) (0.0001)	0.25216	1.425[a]	5.18

	Reduced			0.000056 (0.063) (0.00090)	0.0001 (0.004) (0.9505)	0.27782		7.18
Swiss Franc	Full	0.24742 (2.22) (0.11124)	0.70227 (5.28) (0.13291)	0.001592 (1.50) (0.00106)	0.6887 (34.19) (0.0001)	0.04604	2.512[a]	5.18
	Reduced			0.000105 (0.263) (0.000398)	0.0023 (0.069) (0.7946)	0.05430		5.18
S&P 500	Full	0.271952 (1.80) (0.15142)	0.64774 (3.67) (0.17650)	0.002106 (0.90) (0.002353)	0.3832 (7.21) (0.0050)	0.076685	2.269[a]	5.18
	Reduced			0.000434 (0.39) (0.001125)	0.0074 (0.15) (0.7035)	0.096020		7.18
NYSE	Full	0.229945 (1.74) (0.13204)	0.671400 (3.98) (0.16857)	0.004161 (1.05) (0.003976)	0.5377 (12.63) (0.0004)	0.178330	1.920[a]	5.18
	Reduced			0.000174 (0.103) (0.001689)	0.0005 (0.011) (0.92)	0.216376		7.18

[a] The null hypothesis cannot be rejected at the 5% confidence level.
[b] The null hypothesis cannot be rejected at the 1% confidence level.
[c] F-critical obtained from Table IV of Dickey and Fuller (1981).

TESTS OF RANDOM WALK / 61

Table II
TEST OF RANDOM WALK OF THE MEASURE OF HEDGING EFFECTIVENESS

Model: Full: $Y_t = b_0 + b_1 Y_{t-1} + b_2 T + e_t$ Reduced: $Y_t - Y_{t-1} = b_1 T + e_t$

$$F = \frac{(SSE_a - SSE_r)/2}{SSE_r/(n-3)}$$

$H_0: (b_0, b_1) = (0,1)$

Futures Contract	Model	Coefficients of Independent Variables (t values and std. errors in parenthesis)			R^2 (adj.) (F) (pr.)	SSE	F	F critical[c] 5%, 1%
		b_0	b_1	b_2				
British Pound	Full	0.36964 (3.55) (0.10406)	0.60958 (4.90) (0.12441)	−0.00087 (−0.52) (0.00169)	0.4435 (12.95) (0.0001)	0.17095	6.716[b]	5.18
	Reduced			−0.00019 (−0.226) (0.00086)	0.0017 (0.051) (0.8225)	0.25296		7.18
German Mark	Full	0.26518 (2.85) (0.09322)	0.73544 (6.98) (0.10541)	−0.00110 (−1.65) (0.00067)	0.6164 (25.10) (0.0001)	0.02589	7.122[b]	5.18
	Reduced			−0.00024 (−0.719) (0.00034)	0.0170 (0.518) (0.4774)	0.03906		7.18
Japanese Yen	Full	0.24210 (2.24) (0.10796)	0.72008 (5.83) (0.12344)	0.00119 (1.75) (0.00068)	0.7739 (47.93) (0.0001)	0.01707	2.583[a]	5.18

								F-critical
	Reduced			0.00005 (0.208) (0.00024)	0.0014 (0.043) (0.8364)	0.2022		7.18
Swiss Franc	Full	0.33621 (2.64) (0.12756)	0.61320 (4.03) (0.152028)	0.001204 (1.15) (0.001047)	0.5827 (21.95) (0.0001)	0.04135	3.680*	5.18
	Reduced			0.000048 (0.123) (0.000390)	0.0005 (0.015) (0.9031)	0.05222		7.18
S&P 500	Full	0.362901 (2.58) (0.140466)	0.447433 (2.24) (0.19939)	0.007037 (2.31) (0.003046)	0.5504 (13.24) (0.0003)	0.081003	3.958*	5.18
	Reduced			0.00850 (0.69) (0.00124)	0.023 (0.47) (0.50)	0.116630		7.18
NYSE	Full	0.250761 (1.80) (0.139585)	0.635419 (3.45) (0.184028)	0.003848 (1.53) (0.002521)	0.4813 (10.28) (0.0011)	0.77059	2.134*	5.18
	Reduced			0.000848 (0.76) (0.001121)	0.028 (0.57) (0.4580)	0.095328		7.18

[a] The null hypothesis cannot be rejected at the 5% confidence level.
[b] The null hypothesis cannot be rejected at the 1% confidence level.
[c] F-critical obtained from Table IV of Dickey and Fuller (1981).

Table III

VARIANCE RATIO TEST OF RANDOM WALK HYPOTHESIS OF THE HEDGE RATIO[a]

Foreign Currency		k (quarters)							
		1	2	3	4	5	6	7	8
British Pound	σ^2_k	0.009440	0.006844	0.008301	0.007653	0.007367	0.006999	0.006442	0.006033
	σ^2_k/σ^2_1	1.0000	0.7250	0.8793	0.8107	0.7804	0.7414	0.6842	0.6391
	Z_k		-1.506	-0.443	-0.554	-0.549	-0.573	-0.638	-0.668
German Mark	σ^2_k	0.001558	0.001944	0.001823	0.001694	0.001535	0.001365	0.001281	0.001125
	σ^2_k/σ^2_1	1.0000	1.2478	1.1701	1.0873	0.9852	0.8761	0.8222	0.7221
	Z_k		1.357	0.625	0.256	-0.037	-0.275	-0.357	-0.515
Japanese Yen	σ^2_k	0.021903	0.020844	0.025015	0.030200	0.029728	0.031345	0.031014	0.030229
	σ^2_k/σ^2_1	1.0000	0.9517	1.1421	1.3788	1.3573	1.4311	1.4160	1.3801
	Z_k		-0.265	0.522	1.109	0.893	0.955	0.836	0.704
Swiss Franc	σ^2_k	0.002235	0.002663	0.003149	0.003344	0.003012	0.002568	0.002201	0.001942
	σ^2_k/σ^2_1	1.0000	1.1915	1.4089	1.4962	1.3477	1.1490	0.9848	0.8689
	Z_k		1.049	1.502	1.453	0.869	0.330	-0.031	-0.243
S&P 500	σ^2_k	0.007440	0.006796	0.006847	0.007722	0.006765	0.006025	0.005098	0.004458
	σ^2_k/σ^2_1	1.0003	0.9134	0.9203	1.0379	0.9093	0.8098	0.6852	0.5992
	Z_k		-0.387	-0.239	0.091	-0.185	-0.344	-0.516	-0.605
NYSE	σ^2_k	0.014981	0.016598	0.017452	0.018396	0.015934	0.013222	0.011540	0.011628
	σ^2_k/σ^2_1	1.0000	1.1079	1.1649	1.2280	1.0636	0.8826	0.7703	0.7762
	Z_k		0.483	0.495	0.545	1.298	-0.212	-0.377	-0.338

[a] σ^2_k corresponds to $1/k$ times the variance of the k-differences, that is, $\sigma^2_k = (1/k)$ VAR $(Y_t - Y_{t-k})$; σ^2_k/σ^2_1 is the variance ratio, and Z_k is the normal Z-statistics with $Z_{crit} = 1.96$ for a two-tailed test at the 5 percent of significance level.

Table IV
VARIANCE RATIO TEST OF RANDOM WALK HYPOTHESIS OF THE MEASURE OF HEDGING EFFECTIVENESS[a]

Foreign Currency		k (quarters)							
		1	2	3	4	5	6	7	8
British Pound	σ_k^2	0.013937	0.011529	0.011872	0.013629	0.012063	0.010886	0.010201	0.009716
	σ_k^2/σ_1^2	1.0000	0.8272	0.8518	0.9779	0.8655	0.7811	0.7319	0.6971
	Z_k		−0.962	−0.554	−0.066	−0.342	−0.493	−0.548	−0.570
German Mark	σ_k^2	0.001673	0.002183	0.002444	0.002228	0.001928	0.001861	0.001855	0.001931
	σ_k^2/σ_1^2	1.0000	1.3048	1.4608	1.3317	1.1524	1.1124	1.1088	1.1542
	Z_k		1.697	1.721	0.987	0.387	0.253	0.222	0.290
Japanese Yen	σ_k^2	0.000816	0.001048	0.001276	0.001373	0.001365	0.001213	0.001051	0.000868
	σ_k^2/σ_1^2	1.0000	1.2843	1.5637	1.6826	1.6728	1.4865	1.2880	1.0637
	Z_k		1.583	2.105	2.031	1.710	1.096	0.588	0.120
Swiss Franc	σ_k^2	0.002417	0.001358	0.001682	0.001587	0.001336	0.001528	0.001453	0.001551
	σ_k^2/σ_1^2	1.0000	0.5619	0.6959	0.6566	0.5528	0.6322	0.6012	0.6417
	Z_k		−2.439	−1.136	−1.022	−1.136	−0.8280	−0.815	−0.674
S&P 500	σ_k^2	0.009756	0.005874	0.005990	0.006180	0.005572	0.005345	0.005652	0.006282
	σ_k^2/σ_1^2	1.0000	0.6021	0.6140	0.6335	0.5711	0.5479	0.5793	0.6439
	Z_k		−1.823	−1.187	−0.898	−0.897	−0.838	−0.707	−0.552
NYSE	σ_k^2	0.008596	0.010899	0.012479	0.012484	0.010790	0.009658	0.008448	0.00784
	σ_k^2/σ_1^2	1.0000	1.2679	1.4517	1.4523	1.2552	1.1235	0.9828	0.9160
	Z_k		1.2277	1.389	1.108	0.534	0.229	−0.029	−0.130

[a] σ_1^2 corresponds to $1/k$ times the variance of the k-differences, that is, $\sigma_k^2 = (1/k)\, VAR\, (Y_t - Y_{t-k})$; σ_k^2/σ_1^2 is the variance ratio, and Z_k is the normal Z-statistics with $Z_{crit} = 1.96$ for a two-tailed test at the 5 percent of significance level.

TESTS OF RANDOM WALK   / 65

DISCUSSION OF RESULTS

The empirical tests confirm the hypothesis that the hedge ratios and the measures of hedging effectiveness follow a random walk. One way of interpreting these results is to think in terms of market efficiency. In this sense, the findings reinforce previous research confirming market efficiency in both spot and futures markets. The major implication of this random walk hypothesis is that hedgers cannot consistently place perfect hedges and need to continuously readjust their hedges. This can be done by using appropriate computational methods that take into account the variable nature of the hedge ratio and the measure of hedging effectiveness. A few of these methods are briefly summarized below.

Cechetti, Cumby, and Figlewski (1986) apply the Autoregressive Conditional Heteroskedasticity (ARCH) method to hedging in futures markets. Their approach maximizes the expected logarithmic utility of an investor and gives estimates of optimal hedges. Another methodology which measures hedging effectiveness and which avoids many of the estimation problems caused by nonstationarity in expected returns, is developed in McCabe and Solberg (forthcoming). This technique is based on conditional probability distributions, and the results reported by the authors indicate that varying assumptions about conditional expectations can greatly alter the effectiveness measures. Anderson and Danthine (1982) propose a multiperiod model of hedging which allows for the futures position to be revised within the cash market holding period. Finally, Herbst, Kare, and Coples (1989) estimate optimal hedge ratios by using the ARIMA methodology of Box and Jenkins. Their approach successfully solves the problem of autoregressive disturbances.

The findings of this research imply that the already complex relationships among hedge ratios, measures of hedging effectiveness, volume of trade and open interest require further empirical research. Individual investors, institutional investors, and corporations seeking to reduce or eliminate risk are aware that the hedging process is complicated. It is possible that dynamic hedging is more costly than traditional hedging because the continuous readjustment of the hedge might increase transaction costs. However, the opposite effect is also possible. Herbst, Kare, and Coples (1989) report that their hedge ratios are lower than those rendered by the traditional OLS regression technique which implies a reduction in the required margin deposit and in commissions incurred by hedgers.

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Traditional measures of hedging effectiveness focus on risk reduction. One is the statistic known as the coefficient of determination, or R, which tells the

percent of variance explained by a regression of spot price changes with futures price changes. The higher the R, the lower the minimum variance of the spotfutures or hedged portfolio, and the more effective the hedge. A related measure is the ratio of the standard deviation of the hedged portfolio to that of the unhedged portfolio; the closer this measure is to zero, the more effective the hedge. Though popular measures, a commonly recognized limitation is that these...

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Risk-Return
Hedging Effectiveness Measures for
Stock Index Futures

Mary Lindahl

INTRODUCTION

Traditional measures of hedging effectiveness focus on risk reduction. One is the statistic known as the coefficient of determination, or R^2, which tells the percent of variance explained by a regression of spot price changes with futures price changes. The higher the R^2, the lower the minimum variance of the spot-futures or hedged portfolio, and the more effective the hedge. A related measure is σ_h/σ_u, the ratio of the standard deviation of the hedged portfolio to that of the unhedged portfolio; the closer this measure is to zero, the more effective the hedge. Though popular measures, a commonly recognized limitation is that these measures consider only the risk dimension, ignoring expected returns. During the last few years, measures that include the return dimension have become more common in the literature. For example, Graham and Jennings (1987) use what they term a "return retention" ratio as an additional hedging measure for stock index futures. Also, Howard and D'Antonio (1984, 1987) and Chang and Shanker (1987) introduce and refine what they call "a risk-return measure of hedging effectiveness" that is being used frequently in the literature. These newer measures have serious drawbacks, however, and should not be used to judge the effectiveness of stock index futures hedges.

HEDGING WITH STOCK INDEX FUTURES

Hedging with stock index futures allows portfolio managers to reduce exposure to market risk without altering the composition of their portfolio. For example, consider that the management of the Alaska Permanent Fund has a long-term goal of maintaining 10% of the money in a passively managed portfolio that mirrors the S&P 500 index. They believe, however, that stocks in general are currently overpriced, and they want to reduce exposure to market risk until the market corrects itself. They expect a market correction of 30% to occur in the near future. Two risk-reduction choices available include: (1) selling stocks and buying a risk-free asset such as T-bills; and (2) leaving the stock portfolio as is, and hedging with a short

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position in S&P 500 stock index futures contracts (an opportunity available since 1982 when these contracts were first introduced. Under perfect equilibrium conditions and ignoring transaction costs, these two choices are virtually substitutable in terms of the resulting risk-return combinations. Consider eqs. (1) and (2).

The equilibrium relationship between spot (or cash) prices and futures prices is as follows:

$$f = s + s(i - d) \tag{1}$$

where: f = stock index futures price, s = spot or cash price, i = risk-free interest rate, and d = dividend yield on the spot index.

Equation (1) shows that the equilibrium futures price is equal to the spot price plus the cost of carrying the spot portfolio. The cost of carry is equal to the interest (that is not being earned on the money while it is tied up in stocks) less the dividends (that are being earned on the stocks). In eq. (1), i and d are both yields that are time related and, therefore, the differential becomes less important as the futures contract expiration date is approached. At expiration, the futures price is defined to be equal to the spot price.

The returns on a hedged spot-futures portfolio can be expressed as:

$$R_p = (s_1 - s_0 + D_t - h^*(f_1 - f_0))/s_0 \tag{2}$$

where: R_p = return on the hedged spot-futures portfolio during time period t; s_0, s_1 = spot price at the beginning and end of time period t; f_0, f_1 = futures price at the beginning and end of time period t; D_t = dividends paid during time period t; and h = hedge ratio.

When eq. (2) is restated, with futures prices being expressed as in equation (1), and when a fully hedged position is assumed ($h = 1$), the result is an R_p equal to the risk-free interest rate i.

Consider Figure 1a. The spot (or stock) portfolio is represented by point S and is graphed in risk-return space. Point S corresponds with a hedge ratio (h) of 0 and is the unhedged market return. The straight line between points S and i represent the possible outcomes from the hedged portfolio as the hedge ratio increases from 0 to 1, assuming that futures are always priced at their equilibrium value. Note that line i,S is identical to the Capital Market Line which combines the market portfolio with a risk-free asset. Thus, hedging at equilibrium futures prices produces the same set of risk-return choices as selling stocks and using the money to buy T-bills.

Figures 1b and 1c show typical risk-return profiles for stock index futures hedges compared to the equilibrium limit of line i,S. When basis risk exists, and spot and futures prices are not in perfect alignment, a hedge ratio less than 1 results in the minimum variance position. The curved profile plots under line i,S, as in Figure 1b, when futures are priced to the disadvantage of the short hedger; and the curved profile plots above line i,S, as in Figure 1c, when futures are priced to the advantage of the short hedger.

Note that Figures 1a–c assume that the expected return on the unhedged portfolio (R_s) is greater than the risk-free rate(i). Figures 2a–c show similar relationships when $R_s < i$. Again, a straight line i,S is obtained when futures are always priced at equilibrium (Fig. 2a); the risk-return profile plots below line i,S when futures are priced to the disadvantage of the short hedger (Fig. 2b); and the risk-return profile plots above line i,S when futures are priced to the advantage of the short hedger (Fig. 2c).
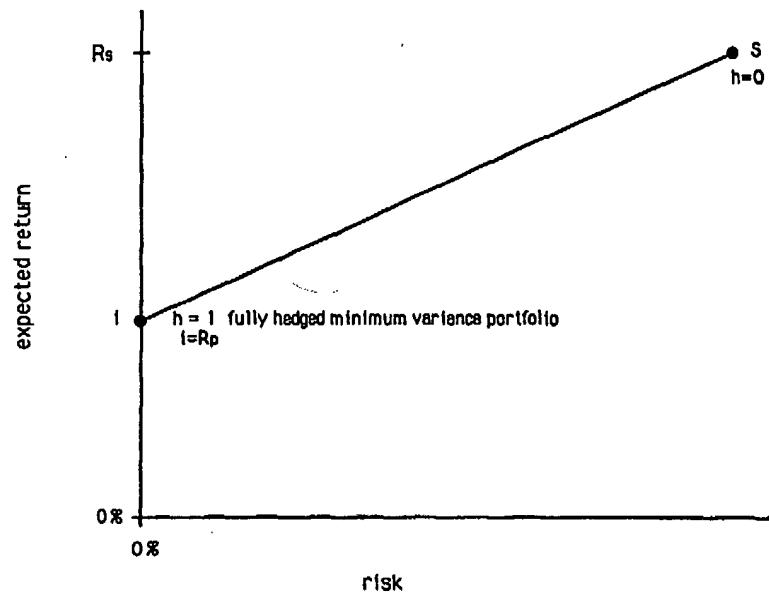
Figure 1a
Risk-return profile when futures are priced at equilibrium and $R_s > i$.
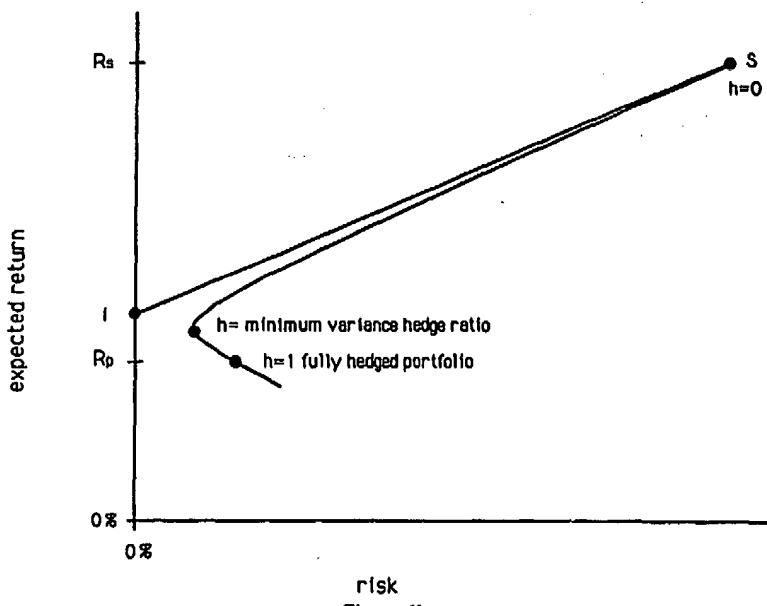

Figure 1b
Risk-return profile when futures are priced to the disadvantage of the short hedger and
$R_f > i$.
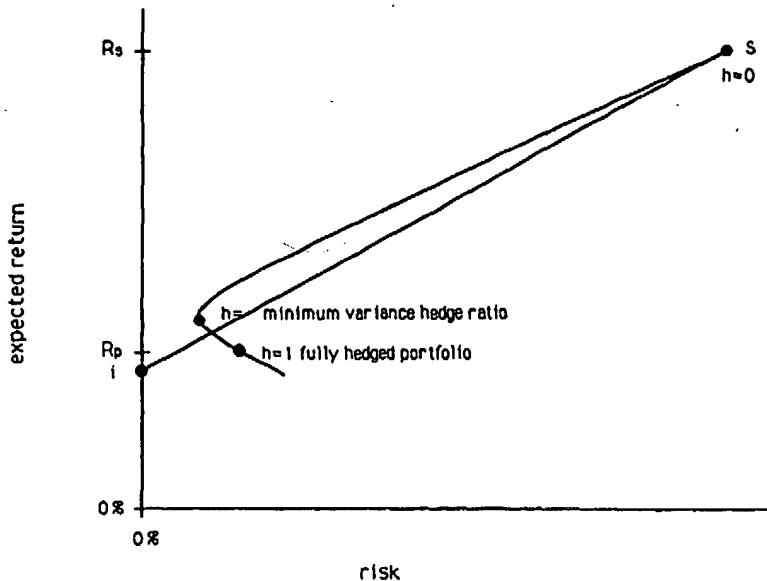
Figure 1c
Risk-return profile when futures are priced to the advantage of the short hedger and
$R_s > i.$

ON MEASURING HEDGING EFFECTIVENESS—THE RETURN DIMENSION

Whenever basis risk exists, as in Figures 1b, 1c, 2b, and 2c, the risk of the hedged portfolio decreases to the point of minimum variance and then increases again. The minimum variance point is the focus of the traditional hedging effectiveness measure; comparing the risk of the minimum variance hedged portfolio to the risk of the spot portfolio indicates the effectiveness of the hedge.

The return dimension is different, however. Whether or not basis risk exists, whenever $R_s > i$, hedged return continually decreases as the hedge ratio increases; and whenever $R_s < i$, hedged return continually increases as the hedge ratio increases. Both the downward sloping and upward sloping straight lines of Figures 1a and 2a illustrate hedges that are 100% effective. Comparing the return of the hedged portfolio to the return of the spot portfolio is, thus, not an appropriate focus for a hedging effectiveness measure. Whether hedged return is greater than or less than spot does not indicate the effectiveness of the hedge. Rather, actual hedged return should be compared to expected hedged return in equilibrium. In other words, the closer the fully hedged return is to the risk-free rate (*i*), the more effective the hedge.

The Graham and Jennings (1987) "return retention" ratio is a clear example of a hedging effectiveness measure that suffers from the wrong focus. It is defined as the ratio of the mean hedged portfolio return to the mean return of the unhedged (spot) portfolio. As just explained, this ratio does not indicate hedging effectiveness. Mean hedged return should be compared to equilibrium hedged return, not
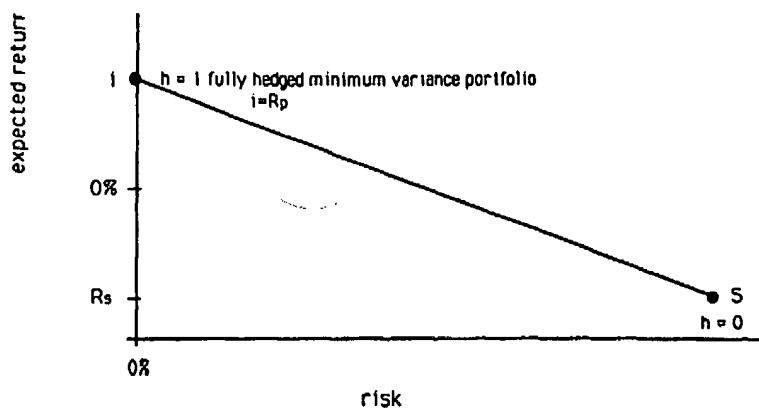
Figure 2a
Risk-return profile when futures are priced at equilibrium and $R_s < 1$.
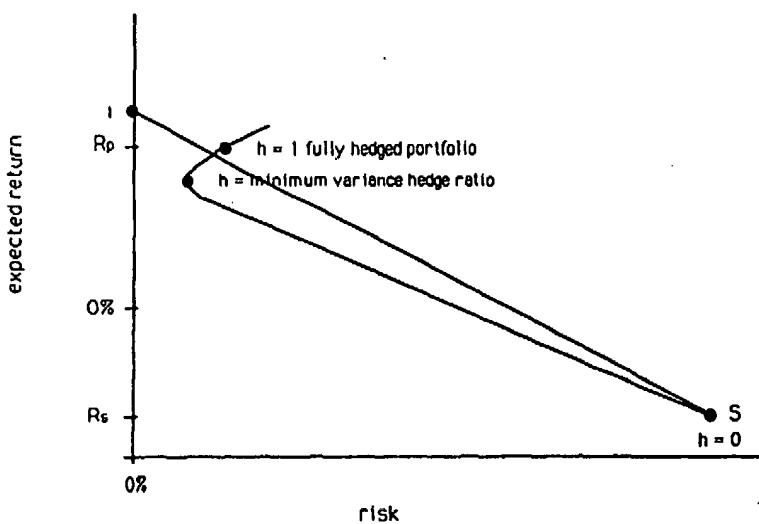
Figure 2b
Risk-return profile when futures are priced to the disadvantage of the short hedger and
$R_s < i$.
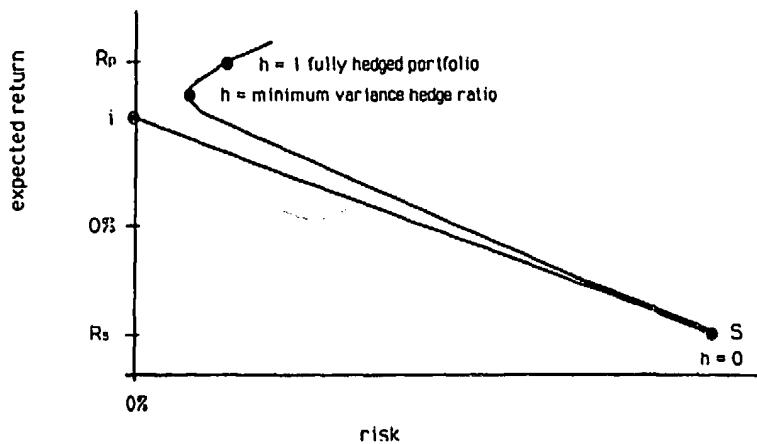
Figure 2c

Risk-return profile when futures are priced to the advantage of the short hedger and
$R_s < i$.

spot return. The Howard and D'Antonio (hereafter HD) and Chang and Shanker (hereafter CS) risk-return hedging effectiveness measures have the same drawback, though the definitions of the HD and CS measures are more complex. Following is a brief review of their measures and the model upon which they are based.

The 1934 HD paper proposed a model where the investors' optimization problem is to choose the appropriate hedge ratio so as to maximize θ_H, the expected excess return per degree of risk of the hedged portfolio:

$$\theta_H = (R_p - i)/\sigma_p \tag{3}$$

where: R_p = expected percentage return of the hedged portfolio, i = risk-free rate of return, and σ_p = standard deviation of the hedged portfolio returns.

Graphically, the model is illustrated in Figure 3. Points S, i, R_p, and R_s are as defined earlier. The curve is a possible risk-return profile as the hedge ratio increases from 0 to the point of minimum variance. Point T is the point of tangency between the hedged portfolio possibility curve and a line from the risk-free asset (i); it is the point where θ_H, the expected excess return per degree of risk, is maximized. According to HD, investors would hold the appropriate number of futures contracts to obtain tangent portfolio T (and this position could be long, short, or zero) and then combine T with the risk-free asset to move to the preferred point on the tangent line. The hedging effectiveness measure based on this model and proposed in HD (1984) is:

$$HE = \theta_H/\theta_s \tag{4}$$

where: $\theta_s = (R_s - i)/\sigma_s$ and σ_s = standard deviation of the spot portfolio returns
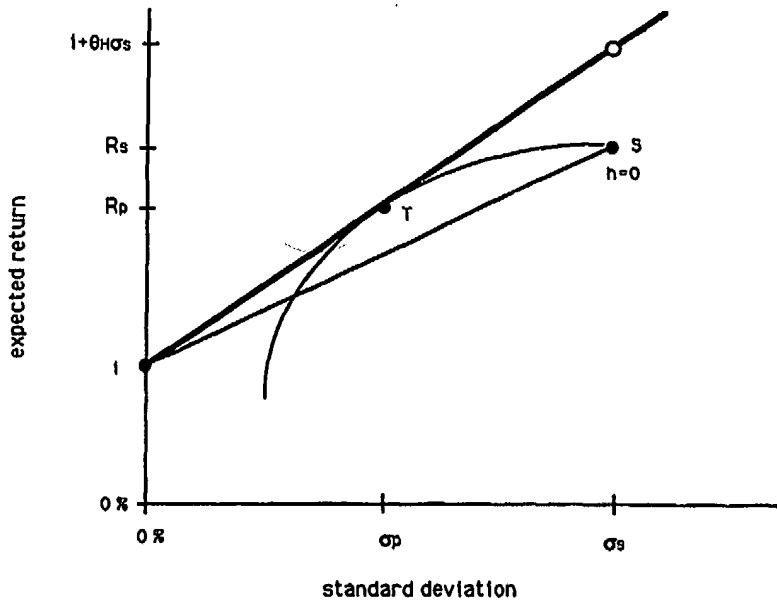
Figure 3
The HD model to maximize expected excess return per degree of risk.

The above *HE* measure is refined by CS (1987), who show that it is inconsistent when the excess return on the spot portfolio ($R_s - i$) is negative. CS suggest the following measure as an alternative:

$$HE_1 = (\theta_H - \theta_s)/|\theta_s| \tag{5}$$

Their measure is positive when θ_H is greater than θ_s, and negative when θ_H is less than θ_s. In their response to CS, HD (1987) agree that their first HE measure is ambiguous, but they criticize HE_1 because it (like *HE*) still has the undesirable property that if the difference between the mean spot return and the risk-free rate is very small or zero, the measure becomes very large. HD derive the following measure, called HBS for hedging benefit per unit of risk, to solve this problem:

$$HBS = (i + \theta_H \sigma_s - R_s)/\sigma_s \tag{6}$$

Note that $i + \theta_H \sigma_s$ is indicated on Figure 3, and represents the amount of return on the line of tangency that corresponds with the σ_s level of risk. HBS is the extra return on the combined hedged-risk-free asset portfolio (compared to the return of the spot portfolio) that can be earned per unit of risk.

Since both HD and CS agree that problems exist with the first HE measure, the following discussion is limited to the HE_1 and HBS measures. A major problem, as in the Graham and Jennings measure, is that the spot portfolio return rather than equilibrium hedged return is the benchmark for measuring effectiveness on the return dimension. Remember, that as basis risk decreases, the hedged risk-return

profile approaches a straight line between the risk-free asset (i) and the spot port-folio (S). Also, as basis risk decreases, θ_H approaches θ_r. So, given the definitions of HE_1 and HBS, the measures are getting smaller and smaller as basis risk approaches zero; at the limit, $\theta_H = \theta_r$ and both HE_1 and $HBS = 0$. Therefore, these measures cannot be used to evaluate the effectiveness of stock index futures hedges.

A NEW RETURN-RISK HEDGING EFFECTIVENESS MEASURE

A hedging effectiveness measure for stock index futures should focus on the differ-ence between actual hedged returns and expected hedged returns in equilibrium. This difference approaches zero as basis risk approaches zero. The sign of the difference indicates whether basis risk is advantageous or not, but does not reflect on the effectiveness of the hedge. For a fully hedged stock portfolio, the equi-librium return is the risk-free rate. This rate is usually approximated by the T-bill rate, which varies for different durations and over time.

Consider again, the scenario described at the beginning of this article, where the manager of the Alaska Permanent Fund stock portfolio is considering hedging with stock index futures as a way to eliminate market risk and lock in current risk-free interest rates. Assume that this hedge is implemented, is lifted three months later, and that the manager must report on the effectiveness of the hedge to the Board of Trustees. The straightforward effectiveness measure, as just explained, is to com-pare the *ex-post* hedged return with the risk-free T-bill rate that could have been earned during the same time period. The smaller the difference, whether positive or negative, the more effective the hedge. Given a T-bill yield of 7%, for example, a hedged return of 6% would be judged as more effective than a hedged return of 10%, even though, of course, 10% is more desirable. Similarly, whether the spot re-turn was −15% or +15% does not influence the effectiveness of the hedge, though it certainly affects the satisfaction quotient.

Imagining the application of a hedging effectiveness measure to an individual hedge helps put the emphasis in the right place—on return rather than risk. The effectiveness of one hedge cannot be measured by traditional risk measures because more than one observation is necessary to compute a standard deviation. When more than one observation exists, however, the standard deviation can certainly be a helpful measure. Imagine now, that the Permanent Fund manager has hedged the stock portfolio a total of 10 times during the past two years, and a report is being made to summarize the effectiveness of the hedges. Effectiveness can then be measured in terms of the mean standard deviation of the difference between portfolio return and the corresponding T-bill rate. The manager might find, for ex-ample, that the average hedge earned a return of 1% above the relevant T-bill rate with a standard deviation of 5%.

The hedging effectiveness measure proposed here is thus a joint return-risk measure and is defined as the mean and standard deviation of the fully hedged portfolio return less the corresponding T-bill rate for the same time period and duration:

$$M_r = \text{Mean of } (R_{pt} - R_{ft}) \tag{7}$$

and

$$\sigma_r = \sigma \text{ of } (R_{pt} - R_{ft}) \tag{8}$$

where: R_{pt} = return of the fully hedged portfolio in time period t, R_{ft} = risk-free T-bill rate for time period t, and $r = (R_{pt} - R_{ft})$.

The mean of the difference in returns, M_r, indicates the percent that fully hedged portfolios earn above or below the risk-free rate, on average. The standard deviation of the difference in returns, σ_r, indicates the dispersion around the mean. The closer M_r is to zero and the smaller the σ_r, the more effective the hedge.

Fortunately, portfolio managers do not need to generate their own hedge data to gather expectations about effectiveness. This section uses the M_r and σ_r measures to analyze the hedging effectiveness of S&P 500 stock index futures. The spot portfolio is represented by a long position in the S&P 500 cash index, and hedging durations of 1, 2, 4, and 13 weeks are examined. Futures data on the S&P 500 index are from the Chicago Mercantile Exchange while cash S&P 500 data and T-bill yields are from the *Wall Street Journal*. Weeks are defined using Friday to Friday closing prices and the futures price is represented by the nearest futures contract in the March–June–September–December series. Equation (2) is used to calculate fully hedged portfolio returns[1] for nonoverlapping periods from 1983–1988. Each hedged portfolio return is matched with the corresponding T-bill yield for the same time period and duration. Over the six years, T-bill yields range from 2.02% to 11.44%. Average T-bill yields for the different durations range from 6.42% to 7.58% and are given in Table I, along with the M_r and σ_r results.

The information in Table I shows that the shorter duration hedges are less effective: the σ_r's are 22.79%, 12.51%, 6.19%, and 2.36% for 1-, 2-, 4-, and 13-week hedges, respectively; and the corresponding M_r's are 1.89%, .59%, .62%, and .79% (all returns are annualized). For each of the durations, the frequency distributions of $(R_{pt} - R_{ft})$ are tested, and the chi square statistics indicate that they approxi-

Table I
RETURN-RISK HEDGING EFFECTIVENESS MEASURES
FOR S&P 500 STOCK INDEX FUTURES

Hedge Duration (Weeks)	M_r[a] Mean of R_{pt}-R_{ft} (%)	σ_r[a] σ of R_{pt}-R_{ft} (%)	Average T-Bill Yield (%)	Number of Observations
1	1.89	22.79	6.42	306
2	.59	12.51	6.74	144
4	.62	6.19	6.72	72
13	.79	2.36	7.58	24

[a]R_{pt} = fully hedged portfolio return, R_{ft} = risk-free rate of return; all returns are annualized.

[1]The empirical analysis in this article assumes a fully hedged portfolio, which is interpreted as using a hedge ratio equal to the beta of the cash portfolio (and beta = 1 in the case of an index portfolio). A debate exists in the literature over whether the cash beta or the minimum variance hedge ratio is ideal. See, for example, Figlewski (1985) and Kawaller (1985). If the minimum variance hedge ratio is preferred, the M_r and σ_r return-risk measures defined in this article can still be used, and the h in eq. (2) would be set equal to the minimum variance hedge ratio. The equilibrium return would also be adjusted to reflect the minimum variance hedge ratio. The minimum variance hedge ratio can be considered a special case of a partially hedged portfolio. And if a portfolio is only partially hedged, the appropriate benchmark return for an equilibrium portfolio can be expressed as $h \cdot R_f + (1 - h) \cdot R_s$.

mate that of a normal curve. Therefore, 68% of the observations are estimated to lie within ±1 SD of the mean, M_r, and about 95% of the observations lie within ±2 SD of M_r. If a risk-free rate of 7% is expected, this translates into average R_p's of 8.89%, 7.59%, 7.62%, and 7.79% for 1-, 2-, 4-, and 13-week hedges, respectively. And the corresponding 95% confidence intervals are: −36.69% to 54.47% for 1-week hedges; −17.43% to 32.61% for 2-week hedges; −4.76% to 20.00% for 4-week hedges; and 3.07% to 12.51% for 13-week hedges. These confidence ranges show that considerable risk exists in the shorter duration hedges. The 13-week hedges are judged to be quite effective, however, with 95% of the returns being within about 5% of the corresponding risk-free rate.

Hedges are subdivided also according to the week prior to contract expiration, and effectiveness measures are calculated for each subset. Table II gives the results. While the 2- and 4-week hedges exhibit no significant patterns, the 1-week hedges show a definite trend toward increased effectiveness as expiration is approached. Hedges that are lifted between 0 and 4 weeks before expiration have an average σ_r of 17.47%, while the hedges 5 to 12 weeks from expiration have an average σ_r of 25.08%. However, all 1-, 2-, and 4-week hedges are judged to be poor substitutes for a risk-free asset. Only the 13-week hedges have returns that are consistently positive.

CONCLUSIONS

This article shows that when stock index futures are priced in equilibrium, fully hedged portfolios earn the risk-free rate of return. The most important indication of hedging effectiveness for stock index futures thus focuses on the difference between ex-post hedged portfolio return and the corresponding risk-free rate $(R_{pt} - R_{ft})$. The Graham and Jennings "return retention" measure and the HD and CS "risk-return" measures all suffer from the drawback that they focus on hedged return vs. spot return rather than hedged return vs. equilibrium return. The study

Table II
HEDGING EFFECTIVENESS MEASURES WHEN SUBDIVIDED
BY WEEK TO EXPIRATION

Weeks Before Expiration	1-Week Hedges		2-Week Hedges		4-Week Hedges	
	M_r	σ_r	M_r	σ_r	M_r	σ_r
0	−2.6	19.21	−2.16	9.55	0.75	6.02
1	1.25	12.9				
2	4.6	19.41	3.47	14.51		
3	3.16	21.31				
4	0.39	14.53	1.58	12.62	−0.32	6.34
5	3.57	23.44				
6	−7.14	21.4	−2.56	12.67		
7	2.38	24.05				
8	−4.89	27.62	2.83	11.49	1.47	6.36
9	10.35	26.46				
10	−3.62	25.3	0.35	13.69		
11	3.87	25.14				
12	15.54	27.25				

defines a new two-part return-risk hedging effectiveness measure as: (1) M_r, the mean of $(R_{pt} - R_{ft})$; and (2) σ_r, the standard deviation of $(R_{pt} - R_{ft})$. The closer both of these measures are to zero, the more effective the hedge.

The M_r and σ_r return-risk measures are applied to six years of S&P 500 stock index cash and futures data to analyze the hedging effectiveness of 1-, 2-, 4-, and 13-week hedges. While the M_r's are less than 2% for all durations, the σ_r's are 22.79%, 12.51%, 6.19%, and 2.36% for 1-, 2-, 4-, and 13-week hedges, respectively. When the hedges are subdivided by week prior to contract expiration, the 1-week hedges show a trend toward increased effectiveness as the contract expiration date approaches. However, all 1-, 2-, and 4-week duration hedges are concluded to be unsatisfactory substitutes for a risk-free asset. Only the 13-week hedges have returns that are consistently positive, with 95% of the returns being within about 5% of the corresponding risk-free rate of return.

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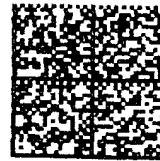
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